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Acute effects of peritoneal dialysis solutions on appetite in non-uremic rats

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Background. Standard peritoneal dialysis (PD) solutions may contribute to anorexia in PD patients due to the peritoneal absorption of glucose from the dialysate, abdominal discomfort and other factors. New PD solutions containing alternative osmotic agents, neutral pH and bicarbonate as buffer were recently developed. To test the effect of these solutions on appetite, we investigated how intraoral (IO) intake of sucrose via an IO cannula was influenced by intraperitoneal (IP) infusion of different PD solutions in an appetite model in rats.

Methods. The IO intake was measured in male Wistar rats after an IP dwell of 30 and 120 minutes with the following PD solutions: 1.36%, 2.27% and 3.86% glucose based and lactate buffered solutions (D); 1.36%, 2.27% and 3.86% glucose based and bicarbonate/lactate buffered solutions (P); 7.5% icodextrin based solution (E); 1.1% amino acid-based solution (N); and, 2.5% glucose-based lactate-buffered solution (GB), using sham injection (injection without infusion) as control. Prior to the tests, rats were provided with an IO cannula, and were trained for two weeks until the rate of IO intake had stabilized.

Results. The D and N solutions inhibited IO intake. For the D solutions, the degree of appetite suppression was higher with the higher concentration of glucose. P 3.86%, but not P 1.36% and P 2.27% solutions, inhibited the IO intake. However, a comparison of the degree of appetite inhibition between D and P showed less inhibition with P 1.36%, 2.27% and 3.86% solutions than with corresponding D solutions. The E solution did not seem to suppress appetite. Finally, no significant difference in IO intake was found between rats given GB 2.5% and D 2.27%.

Conclusions. In this appetite model in rats, the measurement of IO intake after the IP infusion of different dialysis solutions showed that (*1*) N and D solutions may reduce appetite, and for the D solutions the degree of appetite inhibition was related to the dialysate concentrations of glucose; (*2*) the P solutions had less impact on appetite than the D solutions; (*3*) the E solution had no impact on appetite during the short dwells of 30 and 120 minutes. The demonstrated differences between the different solutions appear to be due to different concentrations, and type, of nutrients used as osmotic agent (glucose, amino acids, icodextrin) or buffer (lactate), although differences in dialysate pH, tonicity and concentration of glucose degradation products also may be important. The present studies suggest a possible positive effect on appetite by using bicarbonate/lactate buffered solutions instead of lactate buffered solutions.

Key words: osmotic agents, lactate, bicarbonate, dialysate solutions, anorexia, glucose, malnutrition.

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Anorexia is a common complication that contributes to protein-energy malnutrition and thereby may increase morbidity and mortality in continuous ambulatory peritoneal dialysis (CAPD) patients. Several factors may contribute to anorexia in CAPD patients such as uremic toxicity, unpalatable diets, complicating illnesses, reduced gastrointestinal motility, medication, inflammation and various complications such as peritonitis [1, 2]. However, the peritoneal dialysis (PD) procedure as such also may influence ingestive behavior by causing abdominal discomfort, by absorption of the osmotic agent and other factors [3]. Appetite is regulated by multiple control mechanisms with potential sites of regulation including the brain, the gastrointestinal tract and the liver [4]. Because food intake regulates appetite and post-absorptive metabolism modulates food intake [5], it may be expected that absorption of different nutrients from PD solutions has an impact on appetite in CAPD patients.

The standard PD solutions used today contain unphysiological concentrations of glucose and lactate. Various types of experiments in vitro or in vivo have demonstrated bioincompatibility of conventional PD solutions. These solutions exert their cytotoxic effects through their hyperosmolarity, high concentrations of glucose and lactate, low pH and the presence of glucose degradation products [6, 7]. On the other hand, newer PD solutions have recently been designed to improve the biocompatibility, ultrafiltration capacity and nutritional effects of the solutions via changes in pH, osmotic agents and the

buffer system. The use of bicarbonate, the natural buffering system, has been suggested as a logical way to create a pH neutral and more physiologic solution formulation [8], and the use of a two or three-chambered bag during heat sterilization also limits the generation of glucose degradation products [9]. Furthermore, loss of ultrafiltration capacity due to rapid absorption of glucose, and the possible harmful effects of hypertonic glucose solution on the peritoneal membrane make it important to find effective alternative osmotic agents. The availability of a solution based on glucose polymers (icodextrin) allows the clinician to improve ultrafiltration in both CAPD and automatic peritoneal dialysis (APD) patients during long dwells. Owing to the reduced carbohydrate load, icodextrin also may offer long-term metabolic advantages compared with glucose-based PD solutions [10]. Amino acid-based PD solutions may improve protein nutritional status, particularly in malnourished PD patients. Amino acid-based solutions also may be more biocompatible than glucose based solutions [11].

Hypophagia induced by PD solutions, due to the effect of absorbed nutrients from the solutions, has been reported by our group and others [12, 13]. The inhibition of eating behavior caused by PD solutions may be specific to each nutritional constituent, and not simply an effect of hyperosmolarity or large dialysate fill volume [12, 13]. Ingestive behavior also might be impacted by bioincompatibilities of PD solutions. Since new PD solutions are different as regards biocompatibility and content of nutrients such as glucose, amino acids, icodextrin and lactate, the effect of these PD solutions on eating behavior may be different, too.

The above-mentioned studies indicate that different PD solutions may have an impact on ingestive behavior due to absorption of nutrients and other factors in the solutions. To confirm this hypothesis, we tested intraoral intake of rats in an experimental appetite model after intraperitoneal infusion of different commercial PD solutions.

METHODS

Experimental appetite model

Male Wistar rats (Möllegård breeding laboratories, Ejby, Denmark) weighing 310 to 330 g, with free access to water and pellets were maintained in individual cages in air conditioned, temperature-controlled 22°C colony rooms in which the lights were off between 12.00 and 24.00 hours, as darkness is important for the normal ingestive behavior in the rat. The methods have been described in detail previously [14].

Briefly, in this study, the rats were provided with an intraoral cannula as described below. All surgery was performed under pentobarbital anesthesia [60 mg/kg intraperitoneal (IP); Mebumal, Nordic, Stockholm, Sweden]. The intraoral cannulation was carried out as follows. The rats were placed in a stereotaxis frame and an incision was made in the midline of the scalp. Three screws were fixed in the skull. A 5 cm long PE-100 tubing was then placed between the cheek and gum at a point slightly anterolateral to the first upper molar on the side of the mouth. The tube was advanced subcutaneously and the distal end of the tubing protruded above the surface of the skull, and a 9 mm piece of stainless steel tubing was inserted within the roof of the mouth between the cheek and gum. Dental cement was used to cover and fix the area between the screws and cannula. The animals were allowed three weeks of recovery after surgery. The experimental study was approved by the Animal Ethical Committee of the Karolinska Institute at Huddinge Hospital.

Measurement of ingestive behavior

Prior to the formal experiment, the rats were given a series of training for two weeks initially until the rate of intraoral intake had stabilized. Pellets were removed at 07.00 hours and replaced after testing. The animals were tested for sucrose ingestion at 13.00 hours (one hour after the strong lights were switched off, but using indirect weak light for observation of the test). During the test, the animals were placed in a circular (35 cm diameter) plexiglass arena and had their intraoral cannula connected to a peristaltic pump (Alitea xv; Ventur Alitea, Stockholm, Sweden), which delivered 1 mol/L of sucrose solution at infusion rate of 1 mL/min. This activity of ingestive behavior ends by the time when the animal passively lets food drip from its mouth. The infusion was then interrupted for 30 seconds before restart the infusion. If the rats did not drip food out within one minute, the infusion was continued and interrupted again for 30 seconds when the animal dripped out the solution. This procedure was repeated until the criteria, that is, the rejection of the solution within one minute after a 30 second interruption of the infusion, was fulfilled. The rats could be used repeatedly for testing different solutions. In a separate series of studies, we also investigated the effects of (*1*) no injection, (*2*) sham-injection (injection without infusion), and (*3*) injection of 30 mL of bicarbonate buffered solution without glucose, on an intraoral (IO) intake. The IO intake did not differ between these procedures, indicating that injection and infusion of volume as such had no significant impact on appetite. Thus, no-injection or sham injection was used as control in the present study.

Peritoneal dialysis solutions

The following PD solutions were tested: D solutions (containing 1.36%, 2.27% or 3.86% glucose, lactate 40 mmol/L, pH 5.5); P solutions (two-compartment bag, containing 1.36%, 2.27% or 3.86% glucose, mixture of

Table 1. Characteristics of different commercial peritoneal dialysis (PD) solutions

PD fluid	Osmotic agent *g/dL*	Lactate *mmol/L*	Bicarbonate *mmol/L*	Osmolality *mosm/L*	pH
D	1.36% glucose	40	0	344	5.5
	2.27% glucose	40	0	395	5.5
	3.86% glucose	40	0	483	5.5
P	1.36% glucose	15	25	344	7.4
	2.27% glucose	15	25	395	7.4
	3.86% glucose	15	25	483	7.4
N	1.1% amino acids	40	0	365	6.6
E	7.5% polyglucose	40	0	284	5.6
GB	2.5% glucose	40	0	408	6.0

lactate 15 mmol/L and bicarbonate 25 mmol/L, pH 7.4); N solution (1.1% amino acids, lactate 40 mmol/L, pH 6.6); E solution (7.5% icodextrin, lactate 40 mmol/L, pH 5.6) and GB solution (three compartment bag, containing 2.5% glucose, lactate 38.8 to 40.8 mmol/L, pH 6.0) as shown in Table 1. For these PD solutions, the compositions of buffer are sodium 132 mmol/L, calcium 1.25 mmol/L, magnesium 0.25 mmol/L, and chloride 96 mmol/L.

Experimental procedure

In the following experiments, the intraoral intakes of 1 mol/L of sucrose with the infusion speed of 1 mL/min were measured in one group of rats at 30 minutes and in another group of rats at 120 minutes after the IP infusion of 30 mL of the PD solution. In the experiments, either sham injection or no-injection (pre-test) was used as controls in the separate investigations.

Effects of different glucose concentrations of D solutions on appetite. Sixteen rats were randomly divided into two groups (30 min group and 120 min group). The rats ($N = 8$ in each group) were given an IP infusion of D solutions 1.36%, 2.27%, and 3.86% glucose, and sham-injection (no infusion) respectively, and tested in random order on four consecutive days.

Effects of different glucose concentrations of P solutions on appetite. Sixteen rats were randomly divided into two groups (30 min group and 120 min group). The rats ($N = 8$ in each group) received IP infusion with P solutions 1.36%, 2.27%, and 3.86% glucose, and sham-injection (no infusion), respectively, and tested in random order on four consecutive days.

Effects of N solution on appetite. Sixteen rats were randomly divided into two groups (30 min group and 120 min group). The rats ($N = 8$ in each group) were given N solution and sham injection respectively, and tested in random order on two consecutive days.

Effects of E solution on appetite. Sixteen rats were randomly divided into two groups (30 min group and 120 min group). The rats ($N = 8$ in each group) were given E solution and sham injection, respectively, and tested in random order on two consecutive days.

Table 2. Effect of an IP dwell with 30 mL of 1.36%, 2.27% and 3.86% D solutions on intraoral intake (mL of sucrose, 1 mol/L) after different dwell times

Dwell time	D 1.36%	D 2.27%	D 3.86%	Control
30 min ($N = 8$)	18.2 ± 2.6^a	17.4 ± 2.6^b	16.6 ± 2.2^b	22.0 ± 2.3
120 min ($N = 8$)	19.1 ± 3.6^a	18.1 ± 2.8^a	14.9 ± 4.4^b	22.0 ± 2.7

Data are mean + SD.
[a] Compared to control $P < 0.05$
[b] Compared to control $P < 0.01$

Table 3. Effect of an IP dwell with 30 mL of 1.36%, 2.27% and 3.86% P solutions on intraoral intake (mL of sucrose, 1 mol/L) after different dwell times

Dwell time	P 1.36%	P 2.27%	P 3.86%	Control
30 min ($N = 8$)	22.3 ± 3.8^a	20.7 ± 2.7^a	19.0 ± 3^b	22.2 ± 4.6
120 min ($N = 8$)	22.6 ± 4.1^a	20.4 ± 2.1^a	19.1 ± 2.2^b	22.0 ± 2.4

Data are mean ± SD.
[a] Compared to control $P > 0.05$
[b] Compared to control $P < 0.05$

Effects of GB and D solutions on appetite. Twenty rats were randomly divided into two groups (30 min group and 120 min group). The rats ($N = 10$ in each group) were treated with the 2.5% GB and 2.27% D solution, respectively, and tested in random order on two consecutive days. The intraoral intake of no-injection (pre-test) was used as control.

Analysis of data

The results were expressed as mean ± SD and were analyzed using the unpaired *t* test or paired *t* test when ANOVA test showed significance ($P < 0.05$) with the aid of the Statview (SAS Institute, Inc., Cary, NC, USA) for a personal computer.

To compare the effect of D and P solutions, the degree of appetite inhibition using these solutions was calculated by the formula:

$$\text{Percentage of appetite inhibition (PAI \%)} = (\text{pre-test intake} - \text{post-test intake})/\text{pre-test intake} \times 100. \quad \text{(Eq. 1)}$$

RESULTS

The conventional lactate-buffered glucose-based D solution significantly suppressed the intraoral intake of sucrose in comparison to controls after 30 minutes and after 120 minutes (Table 2). The degree of appetite inhibition was higher with the higher concentration of glucose (Table 2). In contrast, there were no significant differences in IO intake between the bicarbonate buffered 1.36% or 2.27% P solutions and controls at 30 and 120 minutes after the IP infusion (Table 3); however,

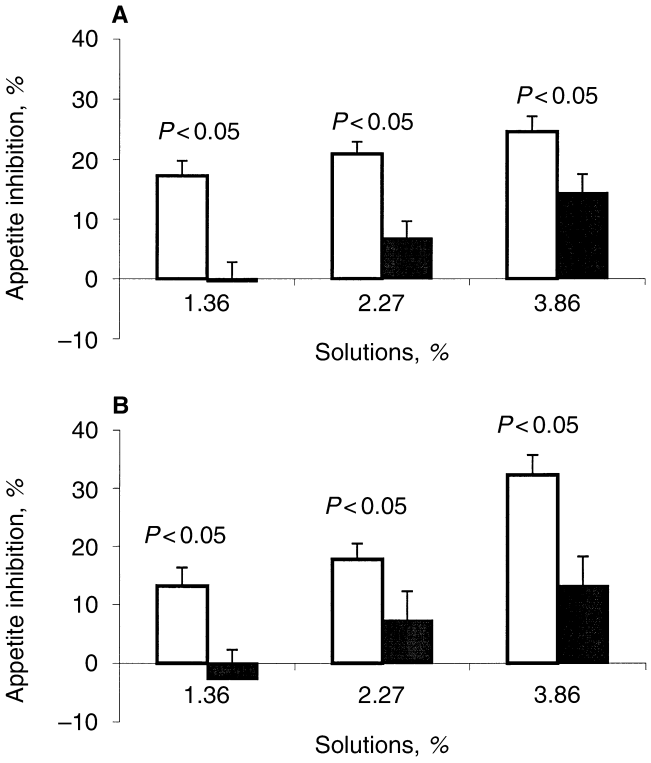

Fig. 1. Appetite inhibition caused by lactate buffered D and bicarbonate/lactate buffered P solutions. Appetite inhibition following an intraperitoneal (IP) dwell 30 mL of D (□) and P (■) solutions was studied after 30 minutes (*A*) and 120 min (*B*). The percentage of appetite inhibition (PAI %) was calculated as the pre-test minus post-test intraoral intake relative to pre-test intake (×100). There were significant differences in PAI % between D and P for 1.36%, 2.27% and 3.86% solutions, respectively ($P < 0.05$).

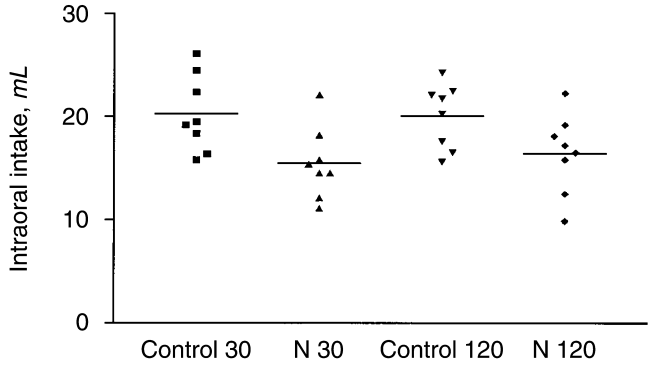

Fig. 2. Effect of N solution on appetite. The amino acid-based N solution significantly inhibited the intraoral intake both at 30 and 120 minutes ($P < 0.05$). Abbreviations are: Control 30, control 30 min (sham-injection); N 30, N solution 30 min; Control 120, control 120 minutes (sham-injection); and N 120, N solution 120 minutes.

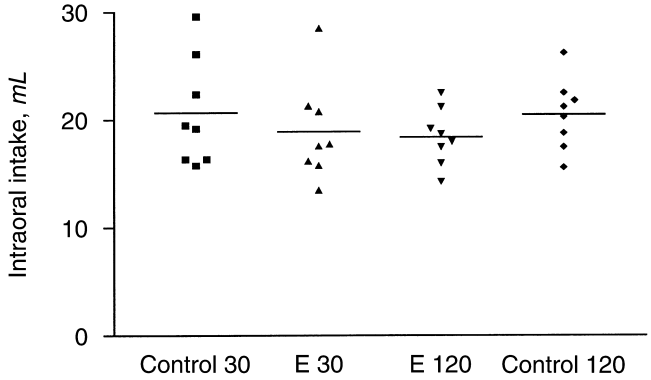

Fig. 3. Effect of E solution on appetite. The intraoral intake in the icodextrin-based E solution group was similar to the control group (sham-injection), and no significant differences were found between 30 and 120 minutes. The numbers 30 and 120 on the horizontal axis denote the number of minutes.

3.86% P solution significantly reduced intraoral intake at 30 and 120 minutes (Table 3).

A separate comparison of D and P solution showed that the percentage of appetite inhibition was more marked with D solution (−17.3%, −21% and −25% for D solutions 1.36%, 2.27% and 3.86%, respectively) than with P solutions (+0.5%, −6.8% and −14.4% for P solutions 1.36%, 2.27% and 3.86%, respectively) at 30 minutes of dwell time (Fig. 1A). The corresponding data at 120 minutes of dwell time (Fig. 1B) were −13%, −17.8% and −32.3% for D solution 1.36%, 2.27% and 3.86%, respectively, and +2.7%, −7.3%, and −13.2% for P solution 1.36%, 2.27% and 3.86%, respectively. These differences were statistically significant for the different concentrations ($P < 0.05$).

The amino acid-based N solution significantly suppressed IO intake in comparison to the control at 30 and 120 minutes of dwell time (Fig. 2). However, the 7.5% icodextrin-based E solution exerted no significant appetite inhibition as compared with control at 30 and 120 min after the infusion (Fig. 3).

Finally, GB 2.5% solution also suppressed appetite and although the effect on appetite inhibition with GB solution 2.5% tended to be less than with D 2.27% solution, there was no significant difference between the two solutions (Fig. 4).

DISCUSSION

For the past years, the depletion–repletion model has dominated the study of food intake. This model proposes that available nutritional substrates (for example, glucose, lipids and amino acids) are constantly monitored with declining amounts triggering meal onset and that the meal is terminated when substrates are sufficiently replenished [15]. The present experiments assessed ingestive behavior quantitatively by measuring the oral consumption of a carbohydrate solution after intraperitoneal infusion of different PD solutions in conscious, free-moving rats. This model has been used earlier in neuropharmacological studies of appetite regulation and

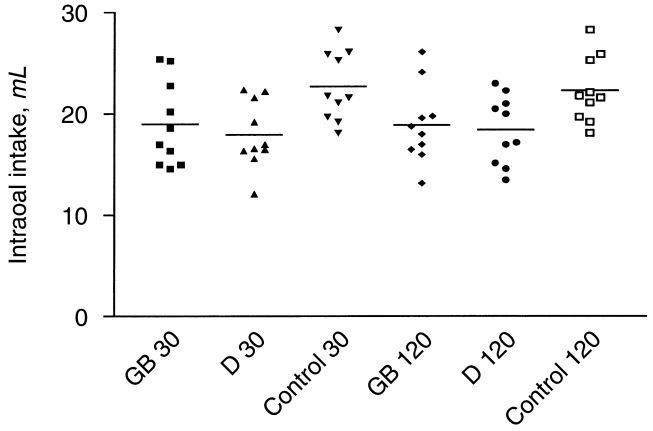

Fig. 4. Effects of GB and D solutions on appetite. There were no significant differences between the 2.5% glucose-based and lactate-buffered (GB) solution and the 2.27% glucose-based and lactate-buffered D solution. Both of the solutions significantly inhibited intraoral intake when compared to the control ($P < 0.05$). Abbreviations of control 30 min (pre-test; no injection), GB 30 min, D 30 min, control 120 min (pre-test; no injection), GB 120 min and D 120 min are respectively Control 30, GB 30, D30, Control 120, GB 120 and D120 on the horizontal axis.

has proven to be accurate and highly reproducible, allowing the same group of animals to be studied repeatedly on consecutive days. A training and adaptive period are required during which the intake of the orally infused solution is gradually increased until a stable intake level is attained [14, 16].

Bicarbonate/lactate buffered solution

The impact of lactate buffered solutions on cell function has been assessed in many in vitro and ex vivo systems, but, despite significant in vitro and ex vivo data indicating its bioincompatibility, lactate-buffered PD solutions have been used almost exclusively in PD [17, 18]. The potential in vivo consequences of repeated exposure to lactate buffered solutions have driven the development and introduction of potentially more biocompatible solutions with a subsequent reduction of the unphysiological components of lactate-buffered PD fluids, such as low pH, high concentrations of lactate, and glucose degradation products [19].

The use of bicarbonate as buffer has made it possible to create a pH-neutral and more physiologic solution formulation [8]. The biocompatibility of bicarbonate buffered solutions has been demonstrated to be better than lactate-based solutions in both in vitro and ex vivo studies [20]. The two-chambered bag used for the bicarbonate/lactate solution also limits the generation of glucose degradation products during the heat sterilization [9]. Clinical studies have shown that the bicarbonate-buffered solution was well tolerated and clinically at least as efficacious as lactate buffered solutions [21]. In the present study, we first tested the effect of conventional D peritoneal dialysis solutions on the food intake in rats, and our data showed that D peritoneal dialysis solutions suppressed appetite and that the degree of suppression was in proportion to the dialysate concentration of glucose. These results suggest that the high concentration of glucose in the PD solutions is one factor determining appetite inhibition. We also found that the P 1.36% and 2.27% solutions did not significantly inhibit intraoral intake, while P 3.86% solution inhibited appetite. It is interesting that the percentage of appetite inhibition was less with P than with D for each glucose concentration. This effect might be due to a combination of factors such as differences in lactate concentration, pH, and glucose degradation products, although more advanced studies are still needed to confirm the mechanism.

Absorption of nutrients as well as utilization of absorbed nutrients from PD solutions may regulate food intake [22]. Lactate is easily reabsorbed into the blood and carried to the liver, where it is oxidized to pyruvate, and pyruvate is then converted into glucose by the gluconeogenic pathway in liver. The metabolism of nutrients such as lactate, pyruvate and glucose in the liver may influence food intake in various way [23, 24]. Oxidation of pyruvate by mitochondrial pyruvate dehydrogenase provides reducing equivalents for the respiratory chain, and it is possible that the generation of reducing equivalents in the mitochondria may be the common feature of the hypophagic effects of these metabolites [25]. In addition, hormonal signals generated by the gastrointestinal tract are sensed directly by the brain so that changes in appetite and food intake occur. Thus, satiety is a result of elevated levels of specific circulating nutrients and gastrointestinal signals [26]. Metabolites, which are directly oxidized by enzymes bound to the mitochondria membrane, also affect feeding. The oxidation of injected metabolites may add to the dynamic process of intermediate metabolism, and thus reduce the threshold at which post absorptive factors contribute to satiety. The rate of energy (ATP) production, associated with the turnover of metabolic fuels, is inversely related to feeding [27, 28]. The role of satiety signals in the control of food intake is thought to occur in response to liver metabolism and hypothalamus secretion [29]. It is generally assumed that there are various types of cells that sense the presence of specific nutrients (such as glucose, protein and lipid) or respond to their rate of metabolism or production of specific metabolites (such as amino acids, lactate and pyruvate), and that these cells are capable of signaling this information to the region of the brain that controls food intake [5, 26].

Furthermore, the bicarbonate/lactate buffered solution has been shown to be associated with less infusion pain than that of lactate buffered solution in PD patients [30]. This might also have contributed to the less inhibitory effect of P solution on intraoral intake as compared to D solution in the present study.

Amino acid-based solution

The amino acid-based N solution was introduced with the dual purpose of providing an alternative osmotic agent and giving supplementary protein to patients with protein malnutrition. The amino acids' supply from dietary protein may influence brain metabolism by providing specific amino acids, which are precursors of major neurotransmitters [31]. It has been proposed that amino acids act as significant components of the control mechanism for protein and energy intake by inducing appetite suppression through their effect on neurotransmitter synthesis. In this study, the intraperitoneal administration of N solution, containing 1.1% amino acids, was found to significantly inhibit carbohydrate intake after a 30 and 120 minute dwell.

It has been suggested that protein intake is physiologically regulated by amino acids accumulating after a meal. The inhibitory effect of amino acids on feeding is mediated by the liver, neurotransmitters, and receptors in the central nervous system [32]. In rats taking a pure protein diet, inhibition of ingestion after a protein meal declines with time in proportion to the plasma concentration of various amino acids. Moreover, there are endogenous satiety factors that are secreted in response to a meal. The best known of these are cholecystokinin, insulin and insulin like growth factor-1 (IGF-1), but several other peptides and cytokines such as leptin, gastric releasing peptide, glucagon and tumor necrosis factor-α have been demonstrated to affect appetite [33, 34]. They may inhibit gastric motility and signaling to the central nervous system via peripheral nerves (vagal afferent fibers), as well as through receptors within the nucleus of the solitary tract in the brainstem area, where the satiety signals are integrated with afferent signals from the tongue and the gastrointestinal system [15, 35]. The above-mentioned pathways for appetite control may perhaps explain why the amino acid-based PD solution injected intraperitoneally in rats was found to inhibit carbohydrate intake in the present study.

Icodextrin based solution

For the long dwell in PD, glucose based solutions are not optimal because of the rapid absorption of glucose, which results in a short duration of net ultrafiltration. In addition, glucose has been implicated in the glycation of proteins in the peritoneal membrane, resulting in diabetiform changes that can lead to further deterioration in membrane properties [36]. Therefore, there is a need for alternative osmotic agents that would enable a more physiological solution to be used during longer dwell periods that have fewer metabolic complications.

The osmotic effectiveness of glucose polymers is now well established and icodextrin is the first colloid osmotic agent used in commercial PD solutions. Owing to its colloidal properties, a 7.5% icodextrin solution exerts an osmotic pressure of only 284 mOsm/L; furthermore, the concentration of glucose degradation products (GDPs) in this solution is very low in comparison to that of standard glucose based solutions [37]. In the present study, no significant reduction of IO intake was found when icodextrin was given IP. It is possible that the normal osmolality, lower content of GDPs, and the slow process of absorption and metabolism of icodextrin contributed to these results. However, a possible appetite inhibitory effect after a dwell time longer than 120 minutes cannot be excluded.

Glucose degradation products

Glucose degradation products (GDPs) develop in glucose-based peritoneal dialysis fluids during heat sterilization and storage [38, 39]. GDPs in PD solutions may cause clinically significant abdominal pain or discomfort during infusion and may therefore affect food intake. However, the present study could not demonstrate a significant difference between GB 2.5% (which contains a significantly reduced amount of GDPs) and the D 2.27% solution. We do not know the exact mechanisms of this unexpected result. The same high lactate concentration, the unphysiological pH and the slightly higher glucose concentration in GB solution than in D solution, or a combination of these factors may have contributed to the lack of differences.

In summary, these studies demonstrate that different peritoneal dialysis solutions have different acute effects on appetite, as assessed by this experimental appetite model in the non-uremic rat. The concentration and properties of nutrients (glucose, amino acids and lactate) in the solutions seem to play a key role in the regulation of appetite. The icodextrin-based solution did not affect appetite during these short-term experiments; however, due to the slow absorption of icodextrin, appetite inhibition after a long dwell cannot be excluded. In addition to the absorption of nutrients from the dialysate, other factors such as low pH, hypertonicity and glucose degradation products also may be important. Furthermore, it should be noted that many factors apart from peritoneal dialysis solutions, such as uremia and concurrent illness, are involved in the complex process of appetite regulation in uremic patients. Therefore, the clinical relevance of these experimental results is not clear. Nevertheless, the present studies indicate a possible beneficial effect on appetite when using bicarbonate/lactate buffered solutions instead of lactate buffered solutions, and possibly, when using the icodextrin based solution, whereas the amino acids-based solution offers no advantage in this respect. Clinical studies of new PD solutions or combinations of the three new solutions should evaluate a possible impact on appetite and food intake.

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